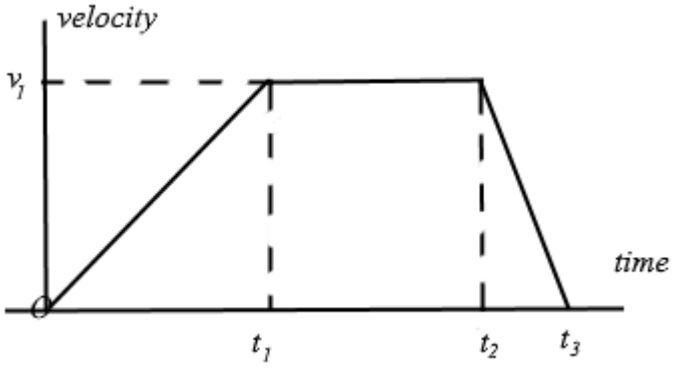
# Section 1: Using calculus

## Exercise level 3 (Extension)

1. One particle moves on a straight line so that its displacement from the origin is given by $s_2 = t^3 + 5t^2 + 4t + 30$; a second moves so that its displacement is $s_1 = t^3 + 4t^2 + 7t + 5$.
   (i) When are the two particles closest together?
   (ii) How far apart are they at that moment?
   (iii) For what range of values of *t* are they moving apart?
   (iv) Is there a time when they are furthest apart?

2. (i) Here is a graph which makes a first attempt to model a short train journey. It is based on observations of the train's speed at times $t_1, t_2$ and on its starting and stopping times.




   (a) Describe in words the three sections of the journey. Write down the values of *v* (velocity) at times $t_1, t_2, t_3$.
   (b) Find *v* as a function of *t* (time) for the model.
   (c) Find an expression for the displacements corresponding to the three sections of the journey in terms of $v_1, t_1, t_2, t_3$.

   (ii) A second model has the form

$$\frac{dv}{dt} = \begin{cases} At(t-t_1) & 0 < t < t_1 \\ 0 & t_1 < t < t_2 \\ B(t-t_2)(t-t_3) & t_2 < t < t_3 \end{cases}$$

   where *A* and *B* are constants. Show that an expression for *v* in terms of *t* using the values from 2(i)(a) to determine *A*, *B* and the constants of integration is

$$v = \begin{cases} \frac{v_1 t^2}{t_1^3}(3t_1 - 2t) & 0 \le t \le t_1 \\ v_1 & t_1 < t \le t_2 \end{cases}$$

   and determine the corresponding form of *v* when $t_2 < t \le t_3$.

   Draw a sketch of the new model's velocity-time graph superimposed on a copy of the graph above. Do you think the new model may be more realistic?

# Edexcel AS Maths Variable acceleration 1 Exercise

3. (i) Compare the displacements of the two models in question 2 over the time interval when the train is accelerating.
   (ii) Calculate the maximum acceleration of the model in question 2(ii) when $0 < t < t_1$ and compare it with the corresponding acceleration of the model in 2(i).